THE BIOLOGY OF THE JUNIPER BERRY INSECTS, WITH DESCRIPTIONS OF NEW SPECIES.*

By S. Marcovitch,
Division of Entomology, University of Minnesota.

In the spring of 1913, Professor Crosby, of Cornell University, suggested that I work out the life history of two chalcids bred by him from deformed berries of *Juniperus virginiana* L. There was also an Eryophyid mite present within the berries, so that at first it was difficult to tell which one deformed the berries and what were the relations between them.

In the fall, I discovered a Tineid larva eating the seeds, while a little later, a Dipterous larva was found eating the fleshy portion of the berry. The latter has proved to be a new species of the family Trypetidæ. Since then, I have found a Cecidomyid larva, and have reared six species of chalcids from the berry, at least two of which are plant-feeding in habit. It seems rather remarkable, at first, to think that so many insects are able to find food in such a small fruit; yet when it is known what a role the mite plays, and how completely the berry is utilized, it does not seem so strange.

The Mite.—Character of the Injury. From the observations of others and from my own examinations, the berry was found to be deformed by the mite, it being classed as a mite gall. Massalongo, 1889, in describing this gall, thought that the mite penetrates the young ovule through the micropyle before the ovule scales become fleshy. Fertilization is thus hindered, and as the scales become fleshy as usual, it is probable that the physiological stimulus of fertilization necessary for growth is substituted by the pathological stimulus of the parasite. Whether or not fertilization is hindered would be difficult to say, as the stigmas of the ovules were open during the beginning of the work of the mites, and once a mite entered the ovule, the berry was found deformed.

The normal berry is more or less cone-shaped while the one-seeded, deformed berries assume a chestnut shape. In the two or more seeded berries, however, the deformation assumes

* Begun at Cornell University; completed at the University of Minnesota.

somewhat the shape of a dumb-bell (Fig. 6, Pl. XII). The mites go in and out through two openings, located at the ends of the berry. These openings are in many cases elevated, and shaped like a miniature volcano, measuring about one-sixth of a millimeter wide at the top. The areas surrounding the openings are yellowish, circular in outline, and very much hardened, thus probably preventing the tissue from growing around the opening by which the mites go back and forth.

Just how this area became hardened, and the various stages leading up to the deformed berry were unknown. At flowering time, however, on May 27, the mites were found in the beginning stages of their work, and the various steps leading up to the deformed berry were traced. Some remarkable changes were found and the interesting feature learned was that the outer hardened area was ovule tissue, and the opening in the center, the stigmal opening of the ovule. In the flower stage, two or three upright ovules are visible (Fig. 1, Pl. XII) surrounded by somewhat thickened scales. A little later, the scales become fleshy and grow over the ovules (Fig. 3, Pl. XII) which seem to sink into the berry after fertilization takes place. If attacked by a mite at this time, the ovules do not sink into the berry, but broaden out and remain on top, the scales growing around them (Fig. 4, Pl. XII, a). The opening of the ovule, then, becomes the opening by which the mites pass back and forth, while the body of the ovule becomes the hardened portion surrounding the opening.

A cross-section of a young, deformed berry about a week old already shows the openings by which the mites pass back and forth to be formed from the old micropyle (Fig. 5, Pl. XII). From this opening, a narrow path leads down into the berry, where it enlarges into a circular burrow. Here one or two reddish mites and from two to ten greenish-white eggs are to be found. After a mite has entered a berry, it becomes deformed and fleshy, the seeds failing to develop. It is probable that the fleshy portion of the deformed berries is made up of more ovule tissue than the normal berries. In this spongy portion, the two phytophagus chalcids are found feeding (Fig. 5, a and b, Pl. XVIII), as well as the mites. The chalcids may, therefore, be considered to be inquilines, since they live in the abode of the mite.

Eriophyes quadrisetus typicus (F. Thom.)*. The body is cylindrical, annulated, gradually tapering to posterior segments. It is very similar to *P. pini.* The body is shorter than in *P. pini,* being about 3 or 4 times as long as broad. The dorsal scutum possesses striations that are not very distinct, one of which is found on the median line and one on each side, both diverging at the posterior end. Laterad of these are two arcs of circles, one on each side, with the concave surfaces facing outward. Near the margin are others that are also curved and incomplete. Seta dorsalis is borne on the sides of the cephalothorax, at a noticeable distance in front of its posterior curvature. It extends forward and upward and beyond the base of S. L., if bent backwards. S. L. are very long, being the longest of the ventral setæ of the abdomen. Caudad of S. L., S. V. 1 are found to be shorter than S. L. S. V. 2 are short, while S. V. 3 attain the posterior extremity of the body. Besides the above-named S. D., there is, further behind, another pair of S. D., which are very short. At the anterior extremity of the scutum, there exists a minute frontal seta. The setæ C. P. are well developed. The S. C. A. are longer than in any other species and very stout, (.025 mm.). S. G. are well developed. The rings are of the same character on both sides. The fifth joint of the legs is somewhat longer than the fourth, having at the end a small, distinct comb with seven pairs of small hairs. The tarsal claw is just a little longer than the comb. The valves of the epigynum are smooth, the posterior one being square.

Length of female	.25 mm.
Width of female	.07 mm.
S. D. anterior	.07 mm.
S. L.	.04 mm.
S. V. 1	.03 mm.
S. C. A.	.02 mm.

Eriophyes quadrisetus juniperus. On January 23, some berries received from Professor C. O. Houghton, of Newark, Del., were found to be deformed in a different manner. Upon examination Mr. Hodgkiss reported the mites to be *Eriophyes quadrisetus* juniperus. In this case, the berry was not fleshy throughout, and seeds were present, the tips of which stuck out of the berry in a conspicuous manner. The normal berries are

* Translated from Canestrini and identified by Mr. Hodgkiss of the Geneva Experiment Station.

blue while the ones infested with this latter variety are green and smaller, the mites being present within the seed. In Europe, *E. quadrisetus* typicus is said to deform the berries of *Juniperus communis* in a somewhat similar manner while *Eriophyes quadrisetus* juniperus works at the bases of the leaves, causing them to swell (Laggerheim 1899).

Egg. The egg is translucent and whitish. It is oval in shape, with bluntly rounded ends. The longer axis measures about 50 μ, and the shorter axis about 35 μ. They occur in great numbers in the berry during the growing season.

Life History. The winter is spent by the mites within the berries, principally in the greener ones and those not eaten out by the chalcids. With the approach of spring, the mites become active, leave the berries, many of which are still on the tree, and begin entering the young ovules. These soon become deformed and eggs are laid in them. Here the young find sustenance and make channels radiating out from the original, central burrow. Through the tiny openings at the ends of the berry, the adults pass to and fro and seek other berries, just past the flower stage, to start new colonies. The production of the young is continuous throughout the growing season. During October, the mites begin to collect in certain berries where they pass the winter, losing most of their greenish color and becoming brownish.

The berries of mature trees are, practically without exception, deformed by the mites, while those of young trees are usually normal. It seems probable that the berries develop quicker in the latter case before the mites have a chance to enter the ovules; while on the old trees, the berries develop slowly enough to enable the mites to get out of their hibernating quarters, and find the ovules before they have become sunken.

The Juniper Berry Chalcid.

Eurytoma juniperinus, n. sp.

Life History. This species is plant-feeding in habit and found in the fleshy portion of the deformed berries, but never in the seed tissue of *Juniperus virginiana.* There is but one generation a year and the winter is passed in the larval stage. On May 26 the insect was already found in the pupal stage, while on May 29 adults were observed emerging. On June 26

an egg was found in the central burrow of the mites, as shown in the diagram (Fig. 6, b, Pl. XVII). The egg was removed to note the length of the egg stage, and after two days of warm weather, the embryo could be seen to be already formed. The head was located on that end where the long pedicel arises from the egg (Fig. 7, Pl. XII), thus agreeing with Triggerson's observations with respect to the orientation of the embryo in the egg (Triggerson, 1914). The mandibles could be seen to be working back and forth in a lively manner, while in the caudal half of the egg could be seen in motion, some oil globules. The neck of the egg was shrunken while the pedicel was curled back over the body of the egg. These larvæ are quite abundant in the mite-infested berries, two or three being often found. They are comparatively active, move about, and devour large portions of the berry (Fig. 5, a, Pl. XVIII).

Female.—Length 2 to 2.3 mm.; thorax 0.7 to 0.8 mm.; abdomen 1 to 1.3 mm. General color black (Fig. 1, Pl. XIII); scape and part of pedicel brownish, rest of antennæ black. Color of legs variable; hind coxæ, femora except knees, and tips of tarsi, black; rest of legs suffused with brownish. Head seen from above transverse, concave behind and convex in front. From the base of the antennæ to clypeus there is a low smooth elevation. Antennal furrows with the sides straight or slightly convergent below. Head and thorax umbilicate-punctate; propodeum coarsely rugose on the sides, the longitudinal median depression broad and shallow, densely and distinctly reticulate-punctate throughout, except sometimes for the longitudinal furrow which is crossed with small transverse ridges. The anterior portion of the propodeum contains three longitudinal carinæ enclosing a smooth quadrilateral area. On the cephalic face of the front coxæ there is a deep diagonal furrow bounded in front by a distinct ridge, which makes a sharp turn near the upper angle. Wings hyaline.

Abdomen conic-ovate, smooth, about three-fourths as wide as long, with a fine sculpture on the anterior half of the segments but fading out on the dorsal surface. Hind margins of segments 2, 3, and 4 nearly parallel (Fig. 3, Pl. XIII). Viewed from the side the dorsal surface of the abdomen presents a nearly straight line, except at the ends. Segments 2, 3, and 4 subequal; the 5 longer than the 3 and 4 together; 7 a little longer than or subequal with the 6. The 6, 7, and tip of sheaths of ovipositor clothed with fine white pile.

Many of the cotypes vary in having more brown on the face, the venter of the prothorax and part of the mesothorax, the abdomen beneath, and legs.

Male.—Length 1.6 to 2.1 mm.; abdomen 0.7 to 0.9 mm. Similar to the female in coloration but much more variable, so that some specimens are nearly all red, all gradations being found. Pedicel and scape brownish, the latter markedly dilated above. In the darker forms, only the proximal portion of the scape is brownish; rest of antennæ dusky. Wing veins brownish or yellowish. The first funicle joint slightly longer than the second, the rest subequal and arched above. Petiole and hind coxæ finely reticulate, the latter about three-fourths the length of the former. Sometimes a brownish spot is present in the darker forms on the upper angle of the prothorax.

Variety Crosbyi.— ♀ similar to the above in coloration and size. The dorsal surface of the abdomen is evenly curved, and not as straight as in *E. juniperinus*. The posterior margins of segments 2 and 3 are nearly parallel, while the posterior margin of the 4 segment meets that of the 3 on the ventral surface. The tip of the abdomen appears to be rather sharp-pointed. The anterior border of the segments of the abdomen with a fine sculpture, that does not fade out on the dorsal surface. Viewed from above all the segments are not visible due to the greater curvature. This form may be a distinct species, and as I intend to work on this genus, further consideration will be given it at a later date.

Described from numerous specimens reared from the berries of *Juniperus virginiana* at Ithaca, New York.

Cotypes deposited in the entomological collection of Cornell University, and in the author's collection, University of Minnesota.

Larva.—(Fig. 1, Pl. XIV). Length about 2.3 mm. Color dull white, mandibles (Fig. 3, Pl. XIV), brownish with a large, sharp tooth in its inner edge. Head and antennal tubercles distinct (Fig. 2, Pl. XIV). Just back of the mandibles is a thick, fleshy labium, slightly lobed and extending beyond the mandibles. On the under side of the labium there is a minute spine, which is elevated on a small tubercle. The setæ on the head and thorax are medium in size, spine-like, and arise from small tubercles, there being eight on the head, ten on each thoracic segment and four shorter ones on each of the abdominal segments. On the mid-dorsal line of each abdominal segment is a large, rounded tubercle, more distinct when the larva is killed in hot water. The spiracles are nine in number, as shown on the diagram, (Fig. 4, Pl. XIV), there being one on the meso- and metathorax, and one on each of the first seven abdominal segments.

On January 10 some of the larvæ were placed in vials on cotton, to check up the adult stage. Similarly, five different kinds of larvæ were taken out of the berry and checked up with the adult forms. The larvæ of *E. juniperinus*, when taken indoors, will pupate in about ten days, gradually turn black, and emerge about four days later.

The Juniper Berry Geniocerus.

Geniocerus juniperi Crawford

This species has been proved to differ from all the other known members of this parasitic group in that it is plant-feeding in habit. They are, by far, the most abundant, there being often as many as eight or ten larvæ in a single berry. The young larvæ were observed from the time they were visible until they were full-grown, and found to live in tight-fitting burrows (Fig. 5 b, Pl. XVIII), that gradually become larger as the insect feeds and grows. This fact alone is sufficient to establish its plant-feeding habits. It is very inactive and a moderate feeder, as compared with the Eurytoma larvæ. There is but one generation a year, and the winter is passed in the larval stage.

"*Female.**—Length about 1.5 mm. Lemon-yellow, with dark brown markings on the rear of the head, front of pronotum, and small brown spot on each lateral angle of pronotum, one on front of axillæ, suture between mesoscutum and scutellum; propodeum medially; spot on each side of abdominal segments and the apical margins of segments more or less suffused with brownish; scape yellow with a brown spot above, rest of antennæ brownish; joints of funicle elongate; seen under high power the antennæ show three ring joints; head and thorax finely sericeous; median furrow of mesoscutum rather indistinct, median pair of furrows on scutellum about half as far apart as length of scutellum; propodeum with median carina hardly as long as the metanotum; submarginal vein with about four bristles; legs yellow with the apical joint of tarsi brown; ventor along median line somewhat brownish; sheaths of ovipositor apically distinctly brown.

Paratypes vary in having more brown, the mesoscutum medially with a large brown spot in front; vertex, parapsidal areas anteriorly, sides of propodeum with brown spots; the abdomen with the bands more pronounced."

As the males are very much fewer in number, I did not succeed in locating one in my rearings until January 2, 1915.

Male.—Length 1.2 mm.; abdomen 0.5 mm. Color lemon-yellow, but the whole dorsal surface much darker than in the female. These darkened areas are more pronounced on the rear of the head, propodeum, furrows of scutellum, and abdomen. The latter has the dorsum brown, excepting for the anterior and posterior extremities, while the apical margins of the segments are darker. The whole ventral aspect lemon-yellow, except for a small area on the prothorax. The antennæ are

* Female to be described by J. C. Crawford, Proc. Ent. Soc., Wash. Male described by author.

similar to *G. marcovitchi* (Fig. 8, Pl. XV). The first joint of the funcile about as long as the pedicel, second joint slightly shorter than the third; third and fourth subequal; club as long as the two preceding joints. Under high power, two ring joints are visible.

Egg.—The egg as dissected out of the female is club-shaped, whitish, with one end wider than the other. Length 0.45 mm.; width of wider end 0.075 mm.; width of opposite end 0.033 mm. (Fig. 14, Pl. XV).

Larva.—Length 1.5 mm. by 0.9 mm. wide. Color dull white with brownish mouth parts. The larva is apparently smooth all over (Fig. 6, Pl. XIV). The head and thorax are not differentiated, the former being reduced to a conical projection, on the end of which are situated the mouth parts. Looking down upon the head, the mouth parts are seen to be situated in a ring (Fig. 7, Pl. XIV), which is heavily chitinized on the dorsal half and to which are attached three prominent lobes, the middle one being the largest. Viewed from the side, these lobes project backward so as to appear like teeth. Within the center of the ring are the two mandibles that project downward into the mouth cavity. Just above them are two slender processes in each side of the ring that might be termed the maxillæ.

Natural Enemies.

On October 30, 1914, I found a parasitic larva in contact (Fig. 9, Pl. XV) with one of the Geniocerus larva, the latter being discolored and dead. Later this species bred out to be *Geniocerus marcovitchi*, Crawf. (Proc. Ent. Soc. Wash., 1915). These parasites breed out in large numbers, and are among the first insects to emerge from the berries when taken indoors. There are apparently two generations and the winter is passed in the larval stage. As the berries remain greenish and pulpy, they would have no difficulty in ovipositing in the fall. Oviposition was observed in the usual way on August 13, lasting about two minutes. When the ovipositor was withdrawn it would apply its mouthparts to the exact spot where it had oviposited, apparently feeding. After a few minutes it would again oviposit in about the same spot, and then feed again. This operation was repeated several times.

Geniocerus marcovitchi.

"*Female.*—Length 2 mm. Blue black or greenish black; joints of the funicle elongate, under high power the antennæ show three ring joints; mesoscutum finely longitudinally sericeous, median furrow on mesoscutum indistinct; metanotum with two yellow spots on disk; propodeum with median carina short, hardly as long as the metanotum; submarginal vein with three or four bristles; legs blue black, the knees, extreme bases and apices of tibiæ and tarsi except apical joint whitish.

Male.—Length 1.75 mm. Similar to the female, the first joint of the funicle about as long as the pedicel, much shorter than the second joint, joints 2 to 4 being subequal in length, club not enlarged, almost twice as long as last joint of funicle, tibiæ yellowish white with a brown stripe inwardly."

Larva.—Length 1.6 mm. and 0.7 mm. wide. Color dull white. The anterior end of larva wider than posterior end, with the head segment rounded. Mandibles very small and pointed. The larva is smooth all over, and composed of fourteen segments.

Egg.—The egg of this species is more or less club-shaped, one end being provided with a long process, while the other end is rounded and tapering (Fig. 13, Pl. XV).

Another parasitic larva was found in the berries but as yet I have not been able to determine its host (Fig. 11, Pl. XV), although it might be parasitic on the Eurytoma larva or phytophagus. When a berry is cut in two, the larvæ are usually to be found in a vertical position and sometimes quite numerous. This larva is rather elongate, spindle-shaped, and pointed at both ends, the hind end being somewhat less acute. It is brownish in color, but lighter at both ends. In the middle of the larva can be seen a conspicuous uric acid concretion that is visible through the skin. There appear to be fourteen segments, with the anal segment bearing two minute spines and slightly lobed. After boiling in caustic potash, the mouth parts are seen to consist of two tiny, pointed mandibles. The pupa is at first brownish in color but later turns black. The sheaths covering the mandibles and lateral edges are very prominent. Length of pupa 1.4 mm., width 0.7 mm.

The Juniper Berry Fruit Fly.

Rhagoletis juniperinus, n. sp.

In the latter part of September, 1913, a Dipterous larva was found feeding upon the fleshy portion of the Juniper berry, at Six-Mile Creek, Ithaca, N. Y. Some were kept indoors, and on April 6 one adult emerged. After careful comparison with many descriptions of related forms, Professor Johannsen found it to be distinct, although closely related to *R. ribicola* Doane.

Life History. It was not until the afternoon of August 12, that an adult male was observed on the tree. On August 21 females were found ovipositing, the process of which lasted about one minute, during which time the ovipositor was worked at an angle of 45 degrees. Just beneath the skin, at this angle,

an egg was later found and dissected out. The egg punctures, which can be found on all sides of the berry, appear as small brown spots, visible to the naked eye, and sometimes with a distinct opening. The fact that the flies appear so late, as compared with other members of the genus, is another example of the adaptation of the time of emergence to the proper stage of the development of the particular fruit. The larvæ mature about October 9, although a few were found in the berries October 27. They pupate about an inch below the surface of the ground. On October 8, however, some were found to have pupated within the berries, which had been picked about two weeks previous, and kept in a glass jar. Two or three pupa were often found within these berries, and once even five, although the berries when examined on the tree, were found to contain but one larva. No holes of any kind were visible on those berries which had been kept in the glass jar. The larvæ eat the fleshy portion of the normal berries and as the young trees have a greater proportion of normal berries, they are much more numerous there.

Female.—Length 3.2 to 4.2 mm.; thorax 1.3 to 1.8 mm. General color, black; head yellowish or brownish; ocellar area dark with space between ocelli and compound eyes more or less suffused with brownish; occiput yellowish brown, except for a few darkened areas which are sometimes arranged radially; antennæ brownish, with the anterior corner of last joint rather sharp; arista black, except for proximal portion; bristles black, except for the post-verticles, which are yellowish. The three facial pairs of bristles convergent, the ocellar pair strongly proclinate, the two fronto-orbital, and vertical pair strictly reclinate (Fig. 6, Pl. XIII).

Thorax shining black with four longitudinal, yellowish bands on dorsum—the inner pair projecting farther forward, and confluent in front. Scutellum black, except for a white rectangular spot on the hinder portion; halters yellow. A striking, bright, alabaster-colored band runs from the humeri to the base of each wing. The thoracic and four scutellar bristles, black.

Abdomen, shining black; posterior border of segments 2, 3, 4, and 5, with a rather broad band of white, the band of the 6th much narrower. Femora, except tips, black, front pair often lighter; tibiæ, trochanters, and tarsi except tips, yellowish-brown; coxæ black, lighter at tip. Wings hyaline, marked with four brown cross bands, as in *R. ribicola* Doane. The first is somewhat oblique, and runs from the humeral vein to the sixth longitudinal vein, along which it gradually fades out beyond the posterior basal transverse vein. The second is much broader, nearly perpendicular, begins on the costa, between the tips of the axillary and

the first longitudinal vein, and extends across the middle of the fifth longitudinal vein, fading out before reaching the posterior margin of the wing. The third is nearly parallel with the second, not quite as broad, runs over the posterior cross-vein and reaches the posterior margin just behind the tip of the fifth longitudinal vein. The fourth band is oblique, completely united with the third on the costal border, and reaches the posterior border at the tip of the fourth longitudinal vein. First longitudinal vein with short, black, bristles. Anterior cross-vein a little oblique, and slightly curved. Anal cell drawn out to a distinct point (Fig. 4, Pl. XIII).

Described from six females and three males, reared from berries of *Juniperus virginiana* at Six Mile Creek, Ithaca, N. Y.

Types in the author's collection, University of Minnesota.

Paratypes deposited in Cornell University.

According to Doane's table of the North American species of Rhagoletis, the present species runs down to *R. ribicola* Doane. The two species may be separated by the following characters:

Anal cell drawn out to a distinct point, spot on scutellum white and small... **juniperinus**

Anal cell not drawn out to a distinct point, spot on scutellum light yellow and larger ..... **ribicola** Doane.

Larva.—Length 6 mm.; width 1.4 mm. Generally dirty white, sometimes slightly greenish (Fig. 1, Pl. XVI). Body rather stout, tapering very little in back, but more in front. Two great hooks (Fig. 11, Pl. XVI). The anterior spiracles (Fig. 6, Pl. XVI) are funnel-shaped, ending in eleven or twelve lobes, each of which, in turn, seem to end in a number of minute pores. The base of the spiracle is made up of polygonal areas. A spinulose area on either side of the dividing line, between segments, from the third and onward, becoming more pronounced towards the venter, where they form the ventral fusiform areas from the fifth to the twelfth segments. A small transverse line is visible on the middle of each ventral segment. The anal tubercles are prominent, and slightly convex. The stigmal plates are about twice their diameter apart, slightly elevated (Fig. 3, Pl. XVI), and composed of three straight slits directed towards the base of the opposite plate (Fig. 10, Pl. XVI). Between the stigmal plates and the anal tubercles are two pairs of distinct fleshy tubercles (Fig. 2 and 3, Pl. XVI), the two nearer the anal tubercles being smaller and a little closer together.

Egg.—Length 0.64 mm.; width about one-fourth of the length. Color whitish with the proximal end yellowish; tip or pedicel brownish. Egg is smooth all over (Fig. 8, Pl. XVI).

The Juniper Seed Caterpillar.

Argyresthia alternatella Kearf.

On September 1, a small caterpillar was found within the seeds of the berries at Six-Mile Creek. On February 12 two moths emerged, and were identified by Mr. August Busck as *Argyresthia alternatella* Kearf. He also informed me that the early stages and life history were unknown, the moths having been collected by. Kearfott in 1908.

Life History. By May 24 the moths were found flying about the trees, and on June 6, eggs were found. These were laid on the stems just below the berries (Fig. 6, Pl. XVIII), while a few were also found lodged on the tips of the scales. By June 24 the berry in cross-section showed three concentric layers within the fused scales. It is probable that the outermost layer, being a part of the ovule, divides and fuses with the scales to form the fleshy portion of the berry. The second layer probably becomes the hard seed-coat, while the inner one becomes the endosperm. It was in the third layer that the earliest stage of the caterpillar was found (Fig. 6, a, Pl. XVII), working its way into the seed, while the seed-coat is still soft, and consuming many of the seeds. The mature larvæ feed on the fleshy portion of the mite-infested berries and, to some extent, on that of the normal berries. The larvæ become full-grown about September 25 and emerge from the berry to build their white, silken cocoons. A few, however, were found in the berry October 30, together with a parasite in contact with one of them. While digging for the pupæ of the fruit flies, I came across the small, silken cocoons, which are formed on the ground, just beneath the grass and sometimes attached to small sticks. The seeds infested by the caterpillar seem to be slightly larger and rounded in shape, while the mite-infested berries are dumbbell-shaped.

"*Adult.**—Head white, palpi golden, antennæ golden fuscus, basal joint paler, thorax white, patagia and posterior end golden; abdomen and legs whitish-ochreous. Expanse 10–12 mm.

Fore-wing. Golden-ochreous, reticulated with brown oblique faciæ. There are five brown spots on costa, about equally spaced between inner 6th and outer 5th. There are three similar spots on dorsal margin at inner 4th, middle and outer 4th; broken brown facia join the costal and dorsal spot, somewhat like a double or jointed letter WV. There is a

* Description from Kearfott. N. Y. Ent. Soc. **16**: 182.

streak of brown on dorsum at base and the apex of the wing is lightly reticulated with this color. Cilia light brownish ochreous on costa and upper half of termen, becoming pale fuscus below middle.

Hind-wing. Light fuscus, cilia with a faint ochreous tinge."

Pupa.—About 4 mm. long by 1.3 mm. wide (Fig. 4, Pl. XVIII). General color greenish, becoming brownish toward maturity. Eyes reddish in mature pupæ. Head, tip of wing pads, tip of abdomen, and 5th, 6th and 7th abdominal segments darker than the rest of the body. General shape cylindrical with abdomen pointed, ending in about seven or eight stout, black spines and reaching a little beyond wing pads. Head bears two conspicuous setæ on each side of the top, two setæ on the front, just laterad of the eyes, and one on each side of the back of the head. A row of eleven smaller setæ on the center and on each side of the dorsum. Six spiracles visible.

Larva.—Length 7 mm. by 1.5 mm. wide (Fig. 1, Pl. XVII). Head brownish, ocellar area, anterior margin of head, and a fine line extending from the ocellar area to the first segment, dark brown. The anterior half of the thoracic and the first eight abdominal segments with an orange-colored band which is more prominent on the dorsal half. The bands of the second and third thoracic segments are somewhat narrowed on the dorsum while that of the first thoracic segment is lighter. The last two segments suffused with red, nearly all over. The remaining portion of the body of the larva is yellowish. Some of the larvæ, however, show very little of the orange color on them. The mandibles are strong bisetose and quadridentate, the two inner teeth being the larger (Fig. 2, Pl. XVII). The antennæ are three-segmented and borne on a fleshy membranous cone (Fig. 3, Pl. XVIII). The first segment is wider than long while the second segment is slightly longer than wide, truncate, and bears a long seta on each side of its apex as well as a small spine and two tubercles, which are about three times as long as broad. The minute third segment is borne on one side of the center, the apex of which bears three small spines and two tubercles, one of which bears a seta and is half as long as the other. The arrangement of the setæ on the third abdominal segment is shown in the diagram (Fig. 7, Pl. XVII). The hooks of the pro-legs and spiracles are brownish, the latter surrounded by a small, circular, yellowish area. The thoracic legs are large at the base but taper rapidly (Fig. 3, Pl. XVII). The first eight abdominal legs are wart-like, ending in about nine hooks that are arranged in a circle, somewhat open on the outer end (Fig. 5, Pl. XVII). The number of hooks seems to vary, thirteen being the highest number found. Pro-legs have about seven hooks. There are nine spiracles, one on the prothorax and one on each of the first eight of the abdominal segments, located in the middle of the orange-colored band.

Egg.—Length 0.33 mm. by 0.2 mm. wide. Shape oval; color, greenish white, with a tinge of purple. The eggs found on the stem are somewhat flattened on the under side, but less so when found on the scales of the berry. The surface of the egg is covered with numerous wavy ridges (Fig. 7, Pl. XVIII).

Natural Enemies.

Secodella sp.—A few specimens of a very beautiful, large, blue chalcid were reared in the winter of 1913 and occurred in much greater numbers the following year. A larva differing from those usually found in the Juniper berries was discovered in December, 1914, among the large particles of excrement characteristic of the Tineid larvæ; hence, I assumed that it was parasitic on the Tineid. After placing a few in vials, the large blue chalcid bred out, the females of which are long and possess a tapering abdomen. This whole subfamily are external feeders on Lepidopterous larvæ. Mr. Crawford of the U. S. National Museum has just informed me that this is a new species, and belongs to the genus Secodella.

Larva.—Length 2.2 mm. General color dull white, with the middle segments brownish (Fig. 6, Pl. XV). Head distinct, with a tubercle on its dorsal surface (Fig. 7, Pl. XV). Antennal tubercles whitish and very prominent. Two tiny, pointed mandibles. In some specimens, the spiracles and tracheal system are visible. Prothorax provided with four minute spines while the other segments apparently do not have any.

Family Encyrtidæ.—On October 17, I dissected out of the caterpillars six parasitic larvæ which were greenish in color and about 1.8 mm. long. The host larva was apparently healthy and crawled around naturally, although a small swelling was visible on one of the abdominal segments. It seems that only about three of the parasites mature in one host larva—the pupæ of these arranging themselves in a peculiar manner. The host larval skin is pushed in, in two places so that the outlines of three pupæ are visible, the anterior one having the head and legs of the host attached to it (Fig. 4, Pl. XVII). The adult is a pretty chalcid, the male having beautifully branched antennæ (Fig. 1, Pl. XV). According to Ashmead's table, this species runs down to the genus Prionomitus (?). I reserve the description of these parasites for a later date.

Protapantales sp.—A few parasites belonging to this genus, as determined by Professor Bradley, were reared. The adults were observed ovipositing on June 11, while the eggs of Arygyresthia were still attached to the berries, hatching at this time. Just before ovipositing, the abdomen is extended and the hind legs are rubbed against each other and over the ovipositor.

Another parasite belonging to the Ichneumonidæ was reared. This species was also found when I opened a pupa of Argyresthia which looked paler than the rest.

The Juniper Berry Midge.

On October 14, 1914, the berries growing along the bluffs of of the Mississippi River, near St. Paul, were found to contain a reddish Cecidomyid larva, together with a Tetrastichus larva in the same cell. The midge larvæ are found only at the bottom of the berry, close to the stem (Fig. 5 c, Pl. XVIII), there being often two or three in one cell. The adults have not, as yet, been bred out. The larva is orange-colored, measuring about 2.5 mm. while the breast bone is elongate, as shown in Fig. 8, Pl. XII. These larvæ were not found to be present in berries from Ithaca, New York.

Distribution and Uses of Juniperus.

The Junipers are widely distributed over the United States although usually not very abundantly. The berries having a rich, aromatic odor, are as yet of no great economic importance. They are, however, used in medicine and, to some extent, by the Germans who use them in making gin and flavoring sauer kraut. They also furnish food for birds. Of greater importance than the berries is the timber furnished by the Juniper trees, the propagation of which is attended with some difficulty. As a result, I have had a number of inquiries regarding sterility of the seed, so that a study of the seed-infesting insects has an economic importance. Berries were received from many locations, as follows:

Boston, Mass.—On October 29 some berries of *Juniperus communis* were received from Boston but were not infested.

Morganstown, W. Va.—Received berries February 1 and found them infested.

Blacksburg, Va.—Received berries January 20 and found the mites present in great abundance, as well as the larvæ of *Geniocerus juniperi*. There was also evidence of the work of the Trypetid larvæ.

Taney County, Mo.—On November 16, received some berries of *Juniperus virginiana* but found them normal.

Kansas State College.—Received berries on November 16 from Charles A. Scott, found no trace of the mites, but did find evidence of the work of the Trypetid and Tineid larvæ.

Pullman, Wash.—Received berries on November 18 from the grounds of the campus but they were not infested.

Durham, N. H.—On November 26 some berries of both *Juniperus virginiana* and *J. communis* were received from Professor Foster. The former were normal but the latter were found to contain Eurytoma larvæ within the seeds of only the green berries, the blue ones apparently not being infested. There was no trace of the mites, but found an egg of the Eurytoma within the seed together with the Eurytoma larvæ.

College Station, Tex.—Received berries on December 28 from Professor A. T. Potts and found them normal.

Fort Collins, Colorado.—On November 10 some berries of *Juniperus scopulorum*, a western species of Juniper, were received. The berries were dried up but found adults of Eurytoma within the seeds, with no trace of the mites. By the presence of the excrement the caterpillar was apparently present.

St. Paul, Minn.—On October 13 berries along the bluffs of the Mississippi River at Fort Snelling, were examined. The mite was present, as well as the Eurytoma and the Tineid and midge larvæ. These berries were very similar to the ones found around Ithaca, New York, excepting that I failed to find the Geniocerus or Trypetid larvæ.

Newark, Del.—On January 23 berries were received from Professor C. O. Houghton. Some dead adult Eurytomas, which were very small, were also found in the seeds. Sometimes a brownish yellow larva, probably belonging to the genus Tetrastichus, was encountered within the deformed seeds that might be parasitic on the Eurytoma, although I was unable to find any evidence.

Logan, Utah.—February 13, received berries from George R. Hill. These were found to be infested by the mites, and there was evidence of the presence of the caterpillar. The berries were not deformed, the species being *Juniperus utahensis*.

I wish to thank all of the above named for kindly sending me berries of the various Junipers.

Method of Work.—Drawings and measurements were made from larvæ killed in hot water and, where possible, from parts mounted on slides. Trachea were studied by putting a few drops of caustic potash or chloroform on the larva and then placing a cover glass over it.

Acknowledgment.—I wish to thank Professors Crosby and Johannsen for their many kind suggestions throughout the work and especially Professor Crosby, at whose suggestion the work was undertaken, and whose aid was invaluable throughout the study.

BIBLIOGRAPHY.

Canestrini, Giovanni. 1892. Famiglia die Phytoptini (in Prospetto Dell Acarofauna Italina per Giovanni Canestrini—Padova, Vol. 5: 609).

Crosby, C. R. 1909. On Certain Seed-Infesting Chalcis Flies. Cornell University Agricultural Experiment Station. Bul. 265.

Doane, R. W. 1898. A New Trypetid of Economic Importance. Entomological News. Vol. 9: 69.

Houard. 1908. On Gall Fauna of Plants. Les Zoocecidies des Plantes v. Europe. Vol. 1: 47; Vol. 3: 1267.

Laggerheim. 1899. Beitrage zur Kenntnis der Zoocecidiem des Wachholders, (Ent. Tidskr., Stockholm, Vol. 20: 114–121.

Massalongo, C. 1889. Intorno ad un Nuovo Tipo di Phytopto—Cecidio del Juniperus communis L. (in Nuovo Giornale Botanico Italiana, Vol. 22: 460.

Nalepa, Alfred. 1910. Eriophyiden Gallenmilben (in . . . Zoologica, original Abhandlungen aus den Gesamtgebiete der Zoologie) p. 212.

Nalepa, Alfred. 1898. (In das Tierreich—Eine zusammenstellung und Kennzeichnung der Resenten Tierformen) p. 5.

Triggerson, C. J. 1914. A Study of Doryphanta Erinacei (Mayr) and Its Gall. Annals of the Entomological Society of America. Vol. 7: 1–60.

EXPLANATION OF PLATES.

Plate XII.

Fig. 1. Flower stage of *Juniperus virginiana* showing the upright ovules.
Fig. 2. Flower stage more advanced showing thickening of the scales.
Fig. 3. Flower stage still further advanced; scales beginning to grow over the ovules.
Fig. 4. A young deformed berry; (a) Top of an ovule not covered by the scales, to be the opening by which the mites pass back and forth; (b) The normal ovule nearly covered by the scales.
Fig. 5. Longitudinal section of a young deformed berry showing the early work of the mites.
Fig. 6. Mature deformed berry; (a) Opening by which the mites pass back and forth.
Fig. 7. Egg of *Eurytoma juniperinus* containing embryo.
Fig. 8. Breast bone of the Cecidomyid larva.

Plate XIII.

Fig. 1. Female of *Eurytoma juniperinus*, (enlarged and modified from a drawing of *E. tylodermatis*, after U. S. Dept. of Agriculture).
Fig. 2. Stigmal club of *E. juniperinus*.
Fig. 3. Abdomen of *E. juniperinus*.
Fig. 4. Wing of *Rhagoletis juniperinus*.
Fig. 5. Antenna of *R. juniperinus*.
Fig. 6. Side view of head of *R. juniperinus*.
Fig. 7. Head of *R. juniperinus* from in front.

Plate XIV.

Fig. 1. Larva of *E. juniperinus*.
Fig. 2. Head of larva of *E. juniperinus*, from in front.
Fig. 3. Mandible of *E. juniperinus*.
Fig. 4. Trachael system of larva of *E. juniperinus*.
Fig. 5. Pupa of *E. juniperinus*.
Fig. 6. Larva of *Geniocerus juniperi*.
Fig. 7. Mouth parts of *G. juniperi* seen under high power.
Fig. 8. Pupa of *G. juniperi*.

Plate XV.

Fig. 1. Adult male parasite of *A. alternatella*. Fam. Encyrtidæ.
Fig. 2. Antenna of same.
Fig. 3. Stigmal club of same.
Fig. 4. Stigmal club of parasite *A. alternatella*. *Secodella sp.*
Fig. 5. Antenna of *Secodella sp.*
Fig. 6. Larva of same.
Fig. 7. Head from in front of larva of same.
Fig. 8. Male antenna of *G. juniperi*.
Fig. 9. Larva of *Geniocerus marcovitchi*.
Fig. 10. Pupa of *G. marcovitchi*.
Fig. 11. Undetermined larva sometimes found in the berries of *J. virginiana*.
Fig. 12. Mouth parts of same.
Fig. 13. Egg of *G. marcovitchi*.
Fig. 14. Egg of *G. juniperi*.
Fig. 15. Mandible of *G. juniperi*.

Plate XVI.

Fig. 1. Larva of *R. juniperinus*.
Fig. 2. Side view of cuadal tip of larva of *R. juniperinus*.
Fig. 3. End of larva of *R. juniperinus*.
Fig. 4. Head end of larva of *R. juniperinus*.
Fig. 5. Sensory papilla of *R. juniperinus*.
Fig. 6. Anterior spiracle of *R. juniperinus*.
Fig. 7. Tip of one of the lobes of the anterior spiracle of *R. juniperinus* (enlarged).
Fig. 8. Egg of *R. juniperinus*.
Fig. 9. Head end of larva of *R. juniperinus* from beneath.
Fig. 10. Stigmal plate of *R. juniperinus*.
Fig. 11. Cephalo-pharyngeal skeleton of *R. juniperinus*.

Plate XVII.

Fig. 1. Larva of *Argyresthia alternatella*. Kearf.
Fig. 2. Mandible of larva of *A. alternatella*.
Fig. 3. Thoracic leg of larva of *A. alternatella*.
Fig. 4. Parasitized larva of *A. alternatella*, showing three mature pupa of the Encyrtid.
Fig. 5. Hooks on prolegs of *A. alternatella*.
Fig. 6. Longitudinal section of a berry showing (a) Young larva of *A. alternatella* in the third layer of the ovule; (b) Egg of *E. juniperinus* in burrow of mites.
Fig. 7. Diagram showing the location of setæ on the first abdominal segment of *A. alternatella*.

Plate XVIII.

Fig. 1. Labium of larva of *A. alternatella*.
Fig. 2. Maxilla of larva of *A. alternatella*.
Fig. 3. Antenna of larva of *A. alternatella*.
Fig. 4. Pupa of *A. alternatella*.
Fig. 5. Longitudinal section of a mature deformed berry.
(a) Larva of *E. juniperinus*.
(b) Larva of *G. juniperi*.
(c) Decidomyid larva.
(d) Mite.
Fig. 6. A young berry showing position of eggs of *A. alternatella*.
Fig. 7. Egg of *A. alternatella*.